

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

IMPROVED FRACTIONATOR WITH  
LIQUID-VAPOR SEPARATION ARRANGEMENT

Inventor: William Lockett, Jr.

Attorney Docket No.      ENC-103C

Assignee: BECHT ENGINEERING COMPANY, INC.

This application is a continuation-in-part of United States Patent Application Serial No. 08/426,160 filed on April 21, 1995, entitled "FRACTIONATOR WITH LIQUID-VAPOR SEPARATION MEANS" by the same inventor herein.

Kenneth P. Glynn, Esq.  
Attorney for Applicant  
Reg. No. 26,893  
Glynn and Associates, P.C.  
24 Mine Street  
Flemington, NJ 08822-1598  
tele (908) 788-0077  
fax (908) 788-3999  
007122100rg-1

007122100rg-1

IMPROVED FRACTIONATOR WITH  
LIQUID-VAPOR SEPARATION ARRANGEMENT  
(Attorney Docket No. ENC-103C)

5           REFERENCE TO RELATED APPLICATIONS

          This application is a continuation-in-part  
of copending United States patent application  
serial number 08\426,160, entitled "FRACTIONATOR  
WITH LIQUID-VAPOR SEPARATION MEANS", which was  
10       filed on April 21, 1995 by the same inventor  
herein.

BACKGROUND OF THE INVENTION

1. Field of the Invention

          This invention relates to a fractionation  
15       vessel having physical separation of a  
fractionation column feed vapor inlet contacting  
zone from a lower temperature liquid pool in  
order to avoid condensation of valuable

0072227 0254260

components in the feed product vapors in the much  
less desirable bottoms liquid. The invention is  
directed to a fractionator with a separate,  
external liquid pool vessel, and a method which  
5 thereby isolates the product vapors from the  
cooler liquid pool. In addition to desired  
thermal separation, the invention provides more  
rapid and uniform quenching of hot liquid  
entering the remotely located bottoms hold-up  
10 pool, plus facilitates lower temperature  
operation of the pool to minimize thermal  
degradation of the bottoms liquid.

## 2. Information Disclosure Statement

The following patents are representative of  
15 the state-of-the-art of fractionation:

U.S. Patent No. 5,326,436 issued to Sampath  
et al. on July 5, 1994 describes a method of  
feeding to a fractionator a feed mixture having a  
wide-boiling range vapor-liquid mixture is  
provided. Also, provided is a fractionator feed  
section adapted to receive a two phase feed  
mixture and has operational stability when fed a  
feed mixture which generates significant volume  
of vapor in the feed section.

U.S. Patent No. 4,714,542 issued to W.  
Lockett, Jr. on December 22, 1987 relates to a  
distillation vapor and feed mixing and subsequent  
separation process and apparatus which involves  
the introduction of a vaporizing liquid feed into  
a flash zone via a tangential nozzle into a  
mixing and separation chamber which directs the

feed into a circumferential path to enhance mixing, and the redirection of rising vapors from the distillation below the flash zone by baffling these vapors into the chamber inlet. The rising vapors are inspirated by the high velocity feed at the inlet side of the chamber and intimate contact and mixing of the rising vapors with the vaporizing feed are enhanced by creating a spinning action. Preferably, the chamber runs peripherally and slightly downward along the inside of wall of the distillation column along an arc no greater than 360°. Alternatively, the mixing section of the mixing and separation chamber may be located outside of the distillation tower and the feed, passing through a jet ejector inspirate the rising vapors.

001221"0295460

Increasing contacting and mixing efficiency in a distillation flash zone increases the yield of more valuable overhead product for the same energy input or permits lower energy input for constant separation between overheads and bottom in the flash zone.

U.S. Patent No. 3,544,428 issued to M.E. Melbom, on December 1, 1970 describes an apparatus for distilling hydrocarbons designed in a stacked fashion so at least two different hydrocarbons, such as different crude oils, may be processed simultaneously, with the distillates being removed as combined products and at least two different bottoms product streams being recovered separately.

U.S. Patent No. 3,502,570 issued to E.L.

00745670-123400

Pollitzer on March 24, 1970 describes concerns a combination process for the production of gasoline fraction rich in high octane aromatics and isoparaffins. Input stream is a relatively low octane gasoline fraction containing substantial quantities of relatively straight chain paraffinic components. Output streams are: the desired high octane gasoline, a light gas stream, a C7 paraffinic cut, and hydrogen.

Process comprises the steps of: low pressure reforming, separation of reforming products, isomerization of a C5 to a C6 fraction, and final product blending. Principal features of the process are: (1) octane number of product gasoline of about 104 F-1 clear, (2) relatively high volume yields of the product gasoline, (3)

relatively uniform distribution of antiknock characteristics as a function of boiling point for the resulting gasoline product.

U.S. Patent No. 3,502,547 issued to R.E.

5           Bridgeford on March 24, 1970 describes a feed  
stream comprising propane, isobutane and C6  
alkylate is introduced into the top section of a  
single fractional distillation column having a  
top section and a bottom section separated by a  
10           solid, vapor impermeable plate. At least one  
downcomer, which serves as the only fluid  
passageway through said plate, extends downwardly  
into the liquid on a tray in the top portion of  
the bottom section to permit the passage of only  
15           liquid from the top section to the bottoms  
section while preventing the passage of vapor

00745670-123100



from the bottom section to the top section. Each section is provided with means for reboiling the liquid contained therein. An overhead product stream containing propane is withdrawn from the top of the top section while an intermediate stream containing isobutane is withdrawn from the top of the bottom section. The bottom section can have a smaller diameter than the top section.

U.S. Patent No. 3,133,014 issued to W.J. Cross, Jr. on May 12, 1964 describes a quench system for synthetic crude wherein a fractionation vessel utilizes an improved arrangement for introduction of quench liquid. A separation tray is not used as in the present invention.

U.S. Patent No. 2,235,329 issued to

E.A. Ocon on March 18, 1941 is directed to a method and apparatus for treating a plurality of heavy hydro-carbon oils for subsequent cracking utilizing a fractionation tower which is typical of the prior art and does not utilize a separation tray and downpipe as is used in the present invention.

U.S. Patent No. 1,744,421 issued to W.F.

Stroud, Jr., Et Al on January 21, 1930 describes a fractionating system comprising a fractionating column, a plurality of fractionating chambers therein at different levels, means for delivering vapors into said column, means for passing reflux liquid in a continuous stream through said column counter current to and in contact with said vapors in the several chambers of said column,

connections from a plurality of said chambers for  
selectively withdrawing liquid therefrom, cooling  
means, a common connection from said connections  
to said cooling means, connections with a  
5 plurality of said chambers for selectively  
returning cooled liquid thereto, and a common  
connection from the discharge of said cooling  
means to said last named connections.

Notwithstanding the above-cited prior art,  
10 the present invention is neither taught nor  
rendered obvious thereby.

SUMMARY OF THE INVENTION

The present invention relates to  
fractionation improvements. Thus, the present  
15 invention includes a fractionator having a  
fractionation vessel, a reactor effluent vapors  
inlet, a vapor feed contacting zone with  
downflowing liquid, a baffled contacting section

09745670 "122100

above the vapor feed contacting zone, a tops  
section above the contacting section, a heavy  
bottoms liquid removal outlet section below the  
vapor feed contacting zone, a bottoms outlet, a  
5 separate, external, remotely located bottoms  
liquid hold-up pool vessel, a bottoms recycle  
system with a heat exchanger to recycle cooled  
bottoms fed back to the fractionation vessel from  
the heavy bottoms liquid hold-up pool vessel to  
10 the heavy bottoms liquid removal outlet section  
and, also, to the fractionation vessel above the  
vapor feed contacting zone. This arrangement  
provides for separating bottoms liquid from vapor  
within the fractionation system for thermal  
15 separation and increased efficiency, wherein  
valuable components of the feed product vapors  
are not condensed and absorbed by the colder  
bottoms liquid pool. This present invention

09745670 122100

arrangement creates a vapor sealing mechanism,  
e.g. a sealing area created at the bottom of the  
fractionator or, preferably, within the bottom  
outlet. The invention also relates to  
5 fractionation process utilizing the aforesaid  
physical fractionator arrangement.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention should be more fully  
understood when the specification herein is taken  
10 in conjunction with the drawings appended hereto  
wherein:

Figure 1 illustrates a schematic flow  
diagram prior art fractionation system;

Figure 2 illustrates a schematic flow  
15 diagram of one embodiment of the invention; and,

Figure 3 illustrates another schematic  
diagram showing a second embodiment of the

00745670-12100

present invention fractionation arrangement.

DETAILED DESCRIPTION OF THE PRESENT INVENTION

Historically, high temperature effluent vapors (typically 950°F to 1050°F) from a process unit reactor (for example, a fluid catalytic cracker) generally enter into a fractionator at a vapor inlet contacting zone wherein the vapors are mixed with a cooler liquid stream that is free falling from above into the vapor inlet contacting zone to lower the reactor effluent vapor temperature (to about 850) in the contacting zone for the purpose for significantly inhibiting undesirable cracking of the valuable reactor effluent product vapors. Liquid gravitating downward from the vapor inlet contacting zone enters a large heavy bottoms liquid hold-up pool section where it is typically

quenched within the liquid pool by introduction  
of a colder stream. This additional quenching  
results in a liquid pool temperature averaging  
about 700°F. This quench is used to mostly

5 control thermal cracking and/or polymerization of  
various components in the bottoms liquid.

Thermal cracking and/or polymerization degrades a  
portion of the pool liquid producing gas and  
soft, sticky-like particulates which cause

10 serious fouling of heat exchangers and equipment  
in the fractionator bottoms liquid pumparound and  
recycle systems.

Reactor effluent vapor streams in Fluid  
Catalytic Cracking Units and Fluid Cokers also  
15 typically contain small hard particles of  
catalyst and coke, respectively, that enter into  
the fractionator column inlet vapor contacting

00745670.123400

zone. These hard particles are normally recovered from the reactor effluent vapors by recirculating a large quantity of fractionator bottoms liquid through a baffled or shed section located immediately above the vapor contacting zone. In addition, this recirculating relatively cooler liquid lowers the hot reactor effluent vapor temperature.

Current operating practice may include a device to distribute the quench liquid stream within the liquid pool. However, the hot liquid from the vapor inlet contacting zone enters the pool in concentrated areas, mostly in the area of the inner vessel wall opposite the feed vapor inlet. Reactor effluent vapors enter into the vapor inlet contacting zone at a velocity of more than 100ft/sec, causing a large portion of the

09745670.122100



liquid droplets to impinge, coalesce and  
gravitate downward in concentrated areas. In  
addition, some of the hard particles recovered  
from the entering reactor vapors, agglomerate  
5 with some of the soft sticky-like coke  
particulates to form larger particles. Injection  
of steam vapors into the bottom of the liquid  
pool is generally practiced to maintain a more  
uniform distribution of the particles in the  
10 bottoms liquid.

Previous and current process economics  
strongly favor operation of the bottoms liquid  
pool at as high a temperature as possible to  
minimize the presence of valuable product  
15 components in the fractionator bottoms liquid.  
However, most refiners are currently obliged to  
operate with a lower than optimum liquid bottoms

temperature in the 640-680°F range specifically  
to limit the amount of thermal degradation of  
bottoms liquid in the pool because of the serious  
equipment fouling problem. In addition, some  
5 refiners inject expensive inhibitors and anti-  
coking chemicals to alleviate the fouling  
problems but with limited success.

Any steps that can be taken to reduce or  
limit bottoms liquid thermal cracking is resorted  
10 to because of the extensive and expensive cost  
for cleaning exchangers and equipment, which  
sometimes forces the refiner to operate below  
target feed rate, resulting in an important  
financial loss. Another important debit in  
15 current operations is the unwanted  
condensation/absorption and loss of valuable  
reactor product components to the bottoms liquid

00745670-122100

purge stream.

In accordance with the invention, a special arrangement with a separate, remotely located bottoms liquid hold-up vessel isolates the fractionator vapor feed inlet contacting zone from the heavy bottoms liquid. By "remotely located" is meant not physically contained within the fractionation vessel itself. This process and apparatus change separates the vapor inlet contacting zone, in which high temperature reactor effluent vapors are contacted with downflowing cooler heavy liquid to obtain a reasonable intermediately high temperature mixture of vapors and liquid that is separated from the much colder liquid pool now located separately from the fractionator column bottom. The intermediately higher temperature liquid

09745670-122100

gravitates from the vapor contacting zone onto the bottom surface of the fractionation vessel, e.g. a sloped bottom surface, to minimize residence time and flows into a central outlet pipe where the liquid then flows into the separate bottoms liquid hold-up pool vessel. In some preferred embodiments, within the fractionation vessel bottom surface is sloped and has a small pool area above an outlet pipe. This small pool area may have a cross section greater than the outlet pipe, but significantly less than half the cross-section of the fractionation vessel itself. At the outlet section either in the aforesaid small pool area, and/or in the outlet pipe itself, the hot liquid is quenched, and is preferably uniformly quenched, to a desired lower temperature before entering the

5

10

15

bottoms liquid hold-up pool vessel. These improvements facilitate fractionator operation at much lower than current normal bottoms pool temperature, well below 750°F, e.g. 650°F to 690°F, to essentially minimize thermal cracking and/or polymerization in the pool and greatly reduce production of harmful sticky-like soft particulates known to seriously plug heat exchangers and other equipment. In addition, these improvements provide a steam blanket between the vapors in the fractionation vessel and the heavy bottoms liquid outlet section to also inhibit product vapor entering into the heavy bottoms liquid. This is accomplished by removing pressurized steam from the top of the separate bottoms liquid hold-up vessel and recycling it into the fractionation vessel just

5

10

15

007227 02954260

above the small pool area of the outlet section.

In addition to important savings in bottoms  
pumparound heat exchanger cleaning costs, the  
present invention arrangement avoids the  
condensation and absorption of valuable product  
components in the fractionator feed vapors by the  
cooler, much lower value liquid in the pool,  
resulting in a higher yield of valuable products  
and reduced recycling of material to the reactor  
which permits some process units to operate at a  
higher fresh feed rate, calculated to be at least  
2 percent. For units operating under a maximum  
feed rate limitation, this can be worth several  
millions of dollars per year to a typical  
refiner. For those units not operating at  
maximum feed rate, reducing recycle flow rate to  
the reactor results in energy savings and yield

credits worth at lease \$1,000,000.00 per year,  
based on 1995 fuel and product values, for a  
typical fluid catalytic cracker.

Thus, the present invention separates the  
hot vapor inlet contacting zone from the colder  
liquid bottoms to avoid/minimize downgrading of  
valuable products. It is also directed toward  
more rapid and uniform quenching of hot liquid  
from the feed contacting zone plus facilitated  
operation at a more optimum bottoms liquid hold-  
up temperature than current operating practice to  
effectively lower thermal degradation of bottoms  
liquid which, otherwise, causes excessive fouling  
and plugging in the fractionator bottoms stream  
heat exchangers and other equipment. This process  
and apparatus are applicable to any  
fractionation, scrubber or distillation column

00745670-123400

but are particularly useful for new and existing  
Fluid Catalytic Cracking Units, Fluid Cokers and  
some Delayed Coker Units in which a much colder  
liquid exists immediately below the fractionator  
5 feed inlet contacting zone.

Figure 1 shows a typical prior art  
fractionator. In Figure 1, the lower portion of  
a fractionation vessel 1 is shown. A stream of  
high temperature reactor effluent vapors 10 is  
10 introduced via line 3 into the fractionator  
column feed vapor contacting zone 5 wherein the  
reactor effluent vapors 10 are partially cooled  
and some of the heavy boiling range unconverted  
reactor feed is condensed by cooler bottoms  
15 liquid stream, shown as liquid stream 45,  
gravitating from the shed baffled contacting  
section 26 located above the feed vapor

09745670.422100



contacting zone 5. The intermediate temperature liquid 13 downflows from the vapor inlet contacting zone 5 directly into heavy bottoms liquid hold-up pool section 18. Quenching liquid 16 contacts the downpouring hot liquid 13 via a quench injection distributor 17. The intermediate temperature liquid 13 flows into the heavy bottoms liquid hold-up pool section 18 in concentrated areas such as the wall area furthest away from line 3. The fractionator bottoms liquid is pumped via pump 19 through pumparound heat exchanger 20, where it is typically cooled by generating steam, and the cooled liquid is conventionally used for quenching liquid 16 and pumparound liquid 21. A small, superheated steam purge line 22, typically enters into the heavy bottoms liquid hold-up pool section 18, to mix

5

10

15

00745670.122100

the solids in bottoms liquid. The product vapors  
25 pass upward from the feed vapor contacting  
zone 5 through the shed contacting baffles or  
other device 38 to mix with the downflowing  
5 cooled bottoms pumparound liquid 21 from  
distributor 27. The baffled contacting section  
26 cools valuable product vapors and condenses  
unreacted feed in addition to recovering fine  
particulates from these vapors. The product  
10 vapors 28 exit upward into the top section 41 for  
further fractionation in the upper portion of the  
fractionation vessel 1. A small bottoms liquid  
purge stream 29, sometimes called recycle or  
cycle oil, consists primarily of very high  
15 boiling range unconverted feed that may be  
typically recycled to the reactor. This prior  
art fractionator results in the various problems

09745670-122100

resulting from trying to maintain liquid pool  
section 18 at low enough temperatures to inhibit  
solids formation, yet high enough to lower the  
loss of valuable products in the bottoms. In the  
5 present invention, the improvement separates the  
hot vapors in the vapor contacting zone from the  
cold liquid and more uniformly and rapidly  
quenches the liquid gravitating from the  
contacting zone. In addition, the pool  
10 temperature can be substantially lowered to  
significantly reduce or eliminate generation of  
fouling material that plagues the bottom liquid  
equipment operation in the prior art  
fractionators.

09745670 122100

This is true both for the temperatures, i.e. at the revised outlet area of the fractionation vessel and at the hold-up pool in the separate bottoms liquid hold-up pool vessel.

5                   Some preferred embodiments of the present invention will be described with reference to Figure 2. In Figure 2, the lower portion of a fractionation vessel 101 is shown. A stream of high temperature reactor effluent  
10                   vapors 110 is introduced via line 103 into the fractionator column feed vapor contacting zone 105 wherein the reactor effluent vapors 110 are partially cooled and some of the heavy boiling range unconverted reactor feed is condensed by  
15                   cooler bottoms liquid stream, shown as liquid stream 145, gravitating from the baffled contacting section 126 located above the feed

0974570-122100

5  
10  
15

typically controlled by thermocouple control  
mechanism 157. The quenched liquid e.g., 650°F  
underflows from the bottom of the steam  
distributor 173 into the heavy bottoms liquid  
small pool area 131. The fractionator bottoms  
liquid is pumped via pump 137. After 137 through  
outlet pipe 133 and tower bottoms level  
controller 144 to control valve 139 into heat  
exchanger 141, where it is typically cooled by  
generating steam. The cooler liquid then flows  
through pipe 143 to remotely located bottoms  
liquid hold-up pool vessel 150, It is controlled  
by flow valve 146, to prevent gaseous or liquid  
back-up. Hold-up liquid 147 may be maintained at  
a temperature of, for example, 450°F, with a cap  
of steam under pressure e.g., 80 psig. Likewise,  
steam exiting bottoms liquid hold-up pool 147 via

09745670-123100

pipe 169 is released downwardly above the small  
pool area 131 through distributor 173 and is  
regulated by controller 171. Superheated steam  
typically enters into the heavy bottoms liquid  
5 hold-up pool vessel 150, via distributor 167, to  
mix the solids in the bottoms liquid (and pass  
upward in the pool to flow through pipe 169 as  
described above). As this steam enters the heavy  
bottoms liquid removal outlet section 112, it  
10 forms an effective steam blanket above the small  
liquid pool area 131 and below the product vapors  
125 above. The product vapors 125 pass upward  
from the feed vapor contacting zone 105 through  
the shed contacting baffles 138 to interact with  
15 the downflowing cooled bottoms pumparound liquid  
121 from distributor 127. In some embodiments,  
flow of this quenching liquid from the bottoms

00745670-123100

liquid hold-up pool vessel 150 and through distributor 127 is controlled by thermocouple control mechanism 135. The shed section 126 cools valuable product vapors and condenses unreacted feed in addition to recovering fine particulates from these vapors. The product vapors 128 exit upward into the top section 141 for further fractionation in the upper portion of the fractionation vessel 101. The small bottoms liquid purge stream 155, sometimes called recycle or cycle oil, consists primarily of very high boiling range unconverted feed that may be typically recycled to the reactor and/or purged from the unit. These are taken from bottom outlet 151 of bottoms liquid hold-up pool vessel 150. Recycle 161 and purge 165 are controlled via level controller 149 and valves 163 and 165

00745670-122100



said in removal rates.

Referring now to figure 3, shown is  
alternative embodiment present invention  
fractionator, having different arrangement from  
that shown in figure 2. However, many of the  
elements shown in fractionation vessel 101 of  
figure 2, as well as some of the elements  
connected thereto, are identical to those shown  
in figure 2. Further, those elements which are  
identical in figures 2 and 3 are identically  
numbered and need not be rediscussed here.

In figure 3, the external remotely located  
bottoms liquid hold-up pool vessel 250 differs  
from that shown in figure 2 in some critical  
aspects, for example, the outlet from  
fractionation vessel 101 feeding into bottoms  
liquid hold-up pool 250 doesn't include a pump or

00745670-13100  
DOTNET 06954260

a steam generating heat exchanger. This enables the figure 3 type embodiments to be operated at different temperatures and pressures than that from figure 2. For example, bottoms liquid hold-up pool 150 of figure 2 is operated at lower pressure and floats on fractionator bottoms pressure. Liquid hold-up pool 250 of figure 3 can operate at higher temperatures of 600° to 700°F, if found desirable.

As shown in figure 3, fractionation vessel 101 has walls 128 which are tapered to the bottom of the fractionation vessel 101, as shown. In this embodiment, there is no small liquid pool at the bottom of fractionation vessel 101 and the actual liquid level is maintained in outlet line 233 by the configuration of the overflow in vessel 250, such as indicated by liquid level

007227" 02954260

line 104. Thus, bottoms liquid removal area 222  
does not contain liquid in a holding pool, and  
recycled steam from bottoms liquid hold-up pool  
250 enters bottom liquid removal area 222 via  
5 pipe 269 and outlet 274, and form a gaseous  
sealing blanket between the vapors in  
fractionation vessel 101 and exiting liquids via  
outlet 233. Flap valve 245 prevents back flow  
through outlet 233. Liquid hold-up 247 contained  
10 in vessel 250 is regulated by controller 249 via  
connection to valve 263 which controls purge and  
recycled flow 261. As in the Figure 2 embodiment  
discussed above, agitation steam 267 is utilized  
in bottoms liquid hold-up pool vessel 250.

15 Liquid 247 is removed from bottoms liquid  
hold-up pool vessel 250 via outlet 251 and  
bottoms pump 237 whereafter it passes through

00745670-133400

heat exchanger 241 and then enters quench recycle  
pipe 255 and outlet pipe 273. As quenching  
liquid it enters outlet 233 at distribution elbow  
259 and the quench liquid flow rate is controlled  
5 by temperature. Sensor 257 and valve 271.

Liquid through outlet pipe 273 is pumped around  
to sheds in drawn off as purge and/or recycle.  
Just as described above, very significant savings  
in valuable product yields, as well as reduced  
10 maintenance costs, result from utilization of  
various embodiments of the present invention.

Obviously, numerous modifications and  
variations of the present invention are possible  
in light of the above teachings. It is therefore  
15 understood that within the scope of the appended  
claims, the invention may be practiced otherwise  
than as specifically described herein.

007227 02954260